An investigation of the circular polarization model for the origin of chiral asymmetry in the early Solar System

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The origin of biomolecular homochirality is a fundamental issue in exobiology. The existence of significant enantiomeric excesses in meteoritic amino acids has been widely discussed in the context of a possible extraterrestrial bias in the prebiotic molecules delivered to Earth during the late accretion phase of planet formation in the solar nebula. The goal of our research program is a critical evaluation of the hypothesis that enantiomeric excesses might be imposed on chiral molecules in an embryonic solar system by its external radiative environment, specifically, by chiral-selective photodissociation resulting from exposure to ultraviolet circularly polarized radiation (CPR). We are carrying out a coordinated program of observational and computational research, in order to better determine the spatial distribution of CPR in regions of active star formation, and to clarify the physical conditions and mechanisms responsible for CPR production in these environments. It is clear from the observations available to date that high levels of CPR are produced most efficiently in regions of high-mass star formation (i.e., regions in which massive stars are present and form alongside lower-mass stars such as the Sun). To better constrain the type of environment that could lead to chiral selection, we have carried out an extended observational study of infrared CPR in the "prototype" massive star formation region OMC-1/M42 in Orion. Our coverage includes both the core and the envelope of the dense molecular cloud OMC-1, and extends into the photodissociation regions closer to the Trapezium cluster where the disks of low mass YSOs are known to be subject to irradiation by their higher mass counterparts. We find that the degree of CPR exhibits a close spatial correlation with the distribution of dust in the molecular cloud: it is generally large in regions of high dust opacity and very low in regions dominated by photodissociation. Whilst the morphology of the observed CP is consistent with a model in which radiation from a central source is scattered by aligned spheroidal grains, we conclude that dichroic extinction by dust in the molecular cloud also plays a major role in its production. The observations are made at near infrared wavelengths because high extinction by dust precludes detection in the ultraviolet within the dense molecular cloud. Our calculations show that the physical mechanisms responsible for the observed infrared CPR can also produce it in the range of ultraviolet wavelengths capable of chiral selection by asymmetric photolysis. However, the polarized flux is likely to be of limited spatial extent and to have lower percentage CP compared with the infrared. We conclude that whilst chiral-selective photodissociation remains a viable model, it requires a special set of physical conditions to be effective.